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Hosono

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(54) **INK JET RECORDING HEAD AND IMAGE RECORDING APPARATUS INCORPORATING THE SAME**

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(52) **U.S. Cl.** **347/70**; 347/68; 347/69; 347/71

(58) **Field of Search** 347/70, 71, 69, 347/68

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(57) **ABSTRACT**

Of the compliance component of a recording head, the volume of a pressure generating chamber is set so that the percentage of the compliance of ink in the pressure generating chamber becomes larger than the percentage of the compliance of pressure generating chamber components such as a partition wall and a vibration plate making up the pressure generating chamber. Accordingly, it possible to decrease variations in the compliance of the recording head without depending only on the accuracy of finishing.

24 Claims, 5 Drawing Sheets

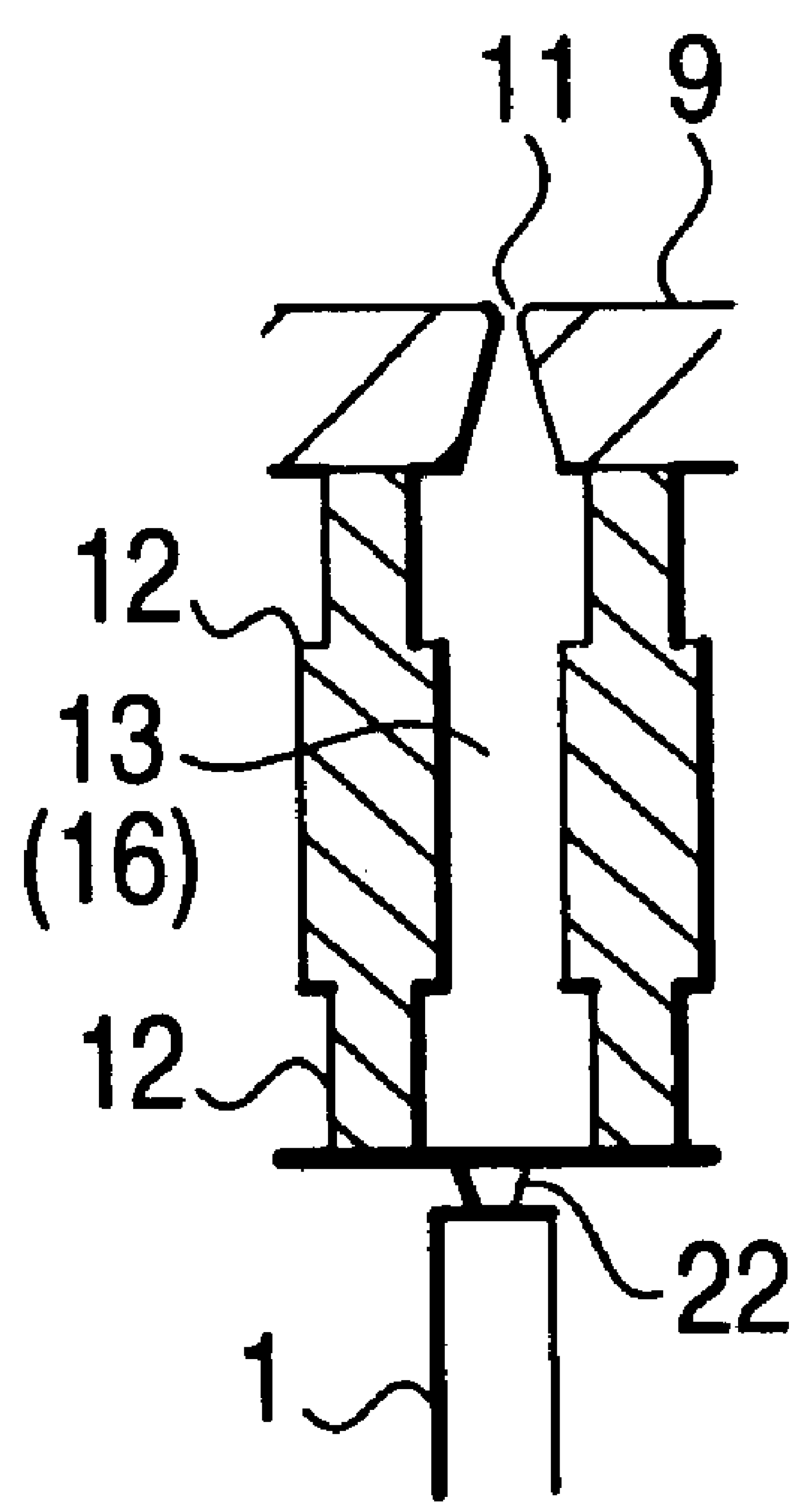


FIG. 1

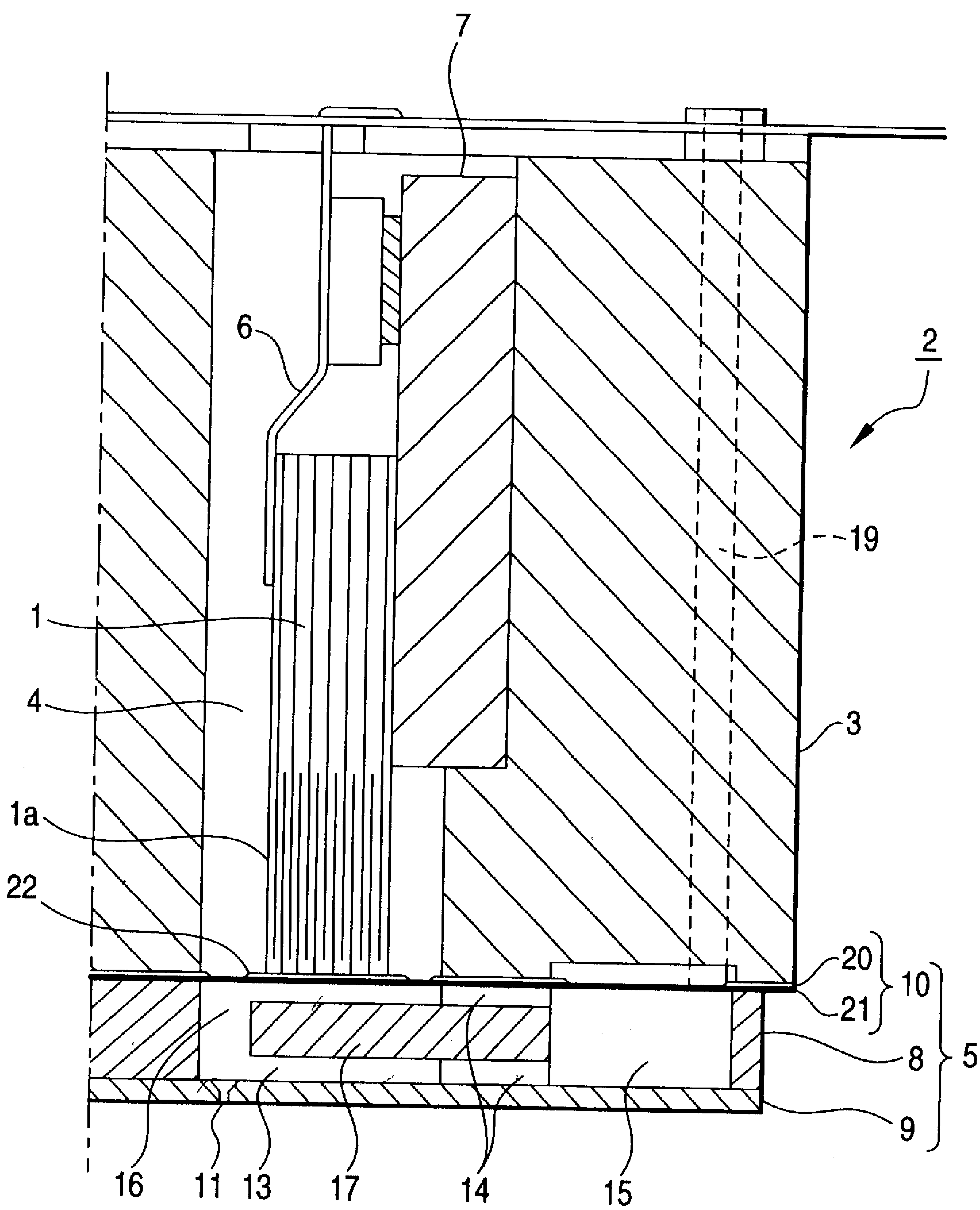


FIG. 2A

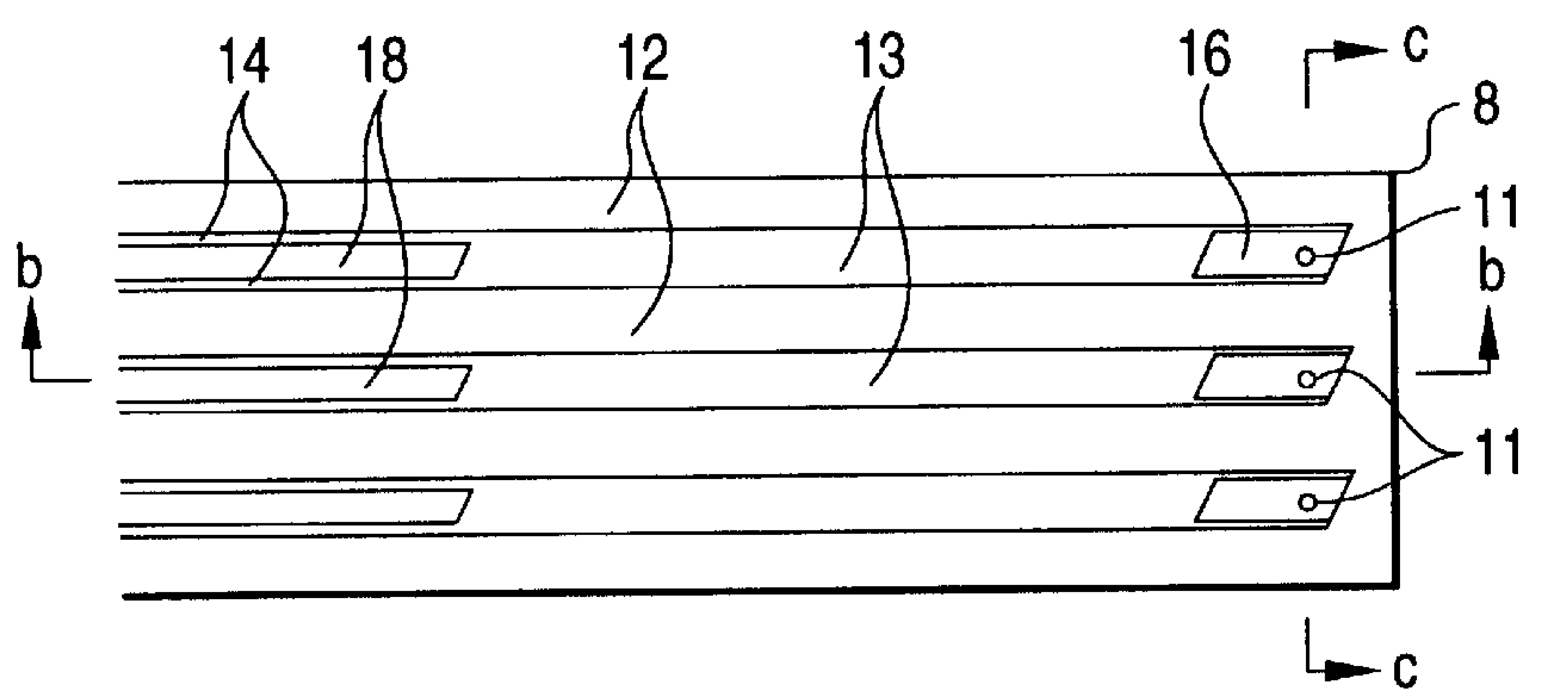


FIG. 2B

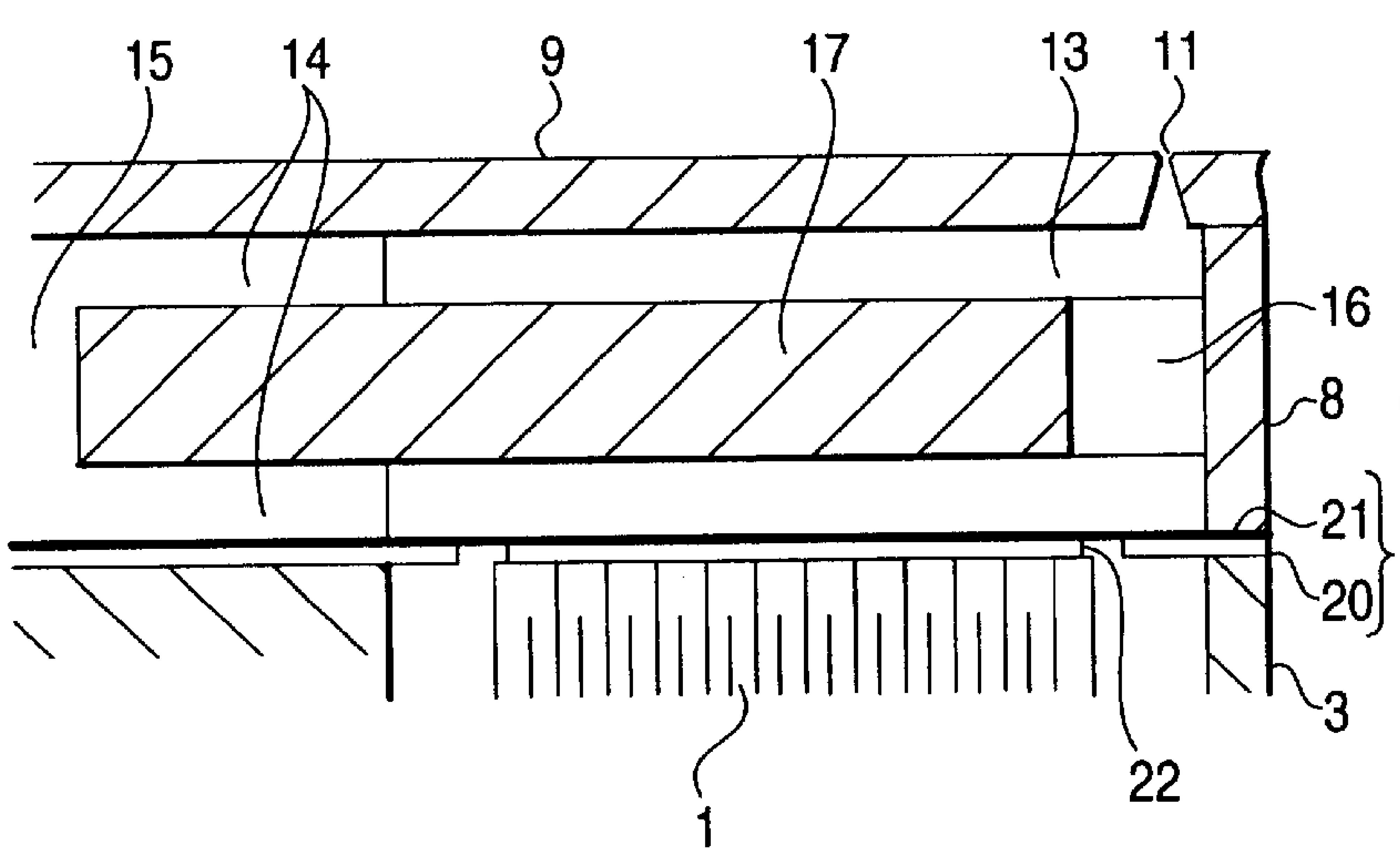


FIG. 2C

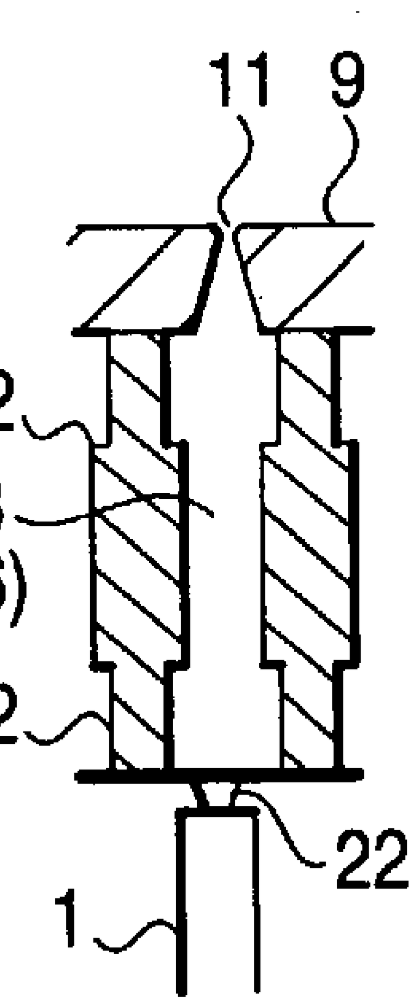


FIG. 3

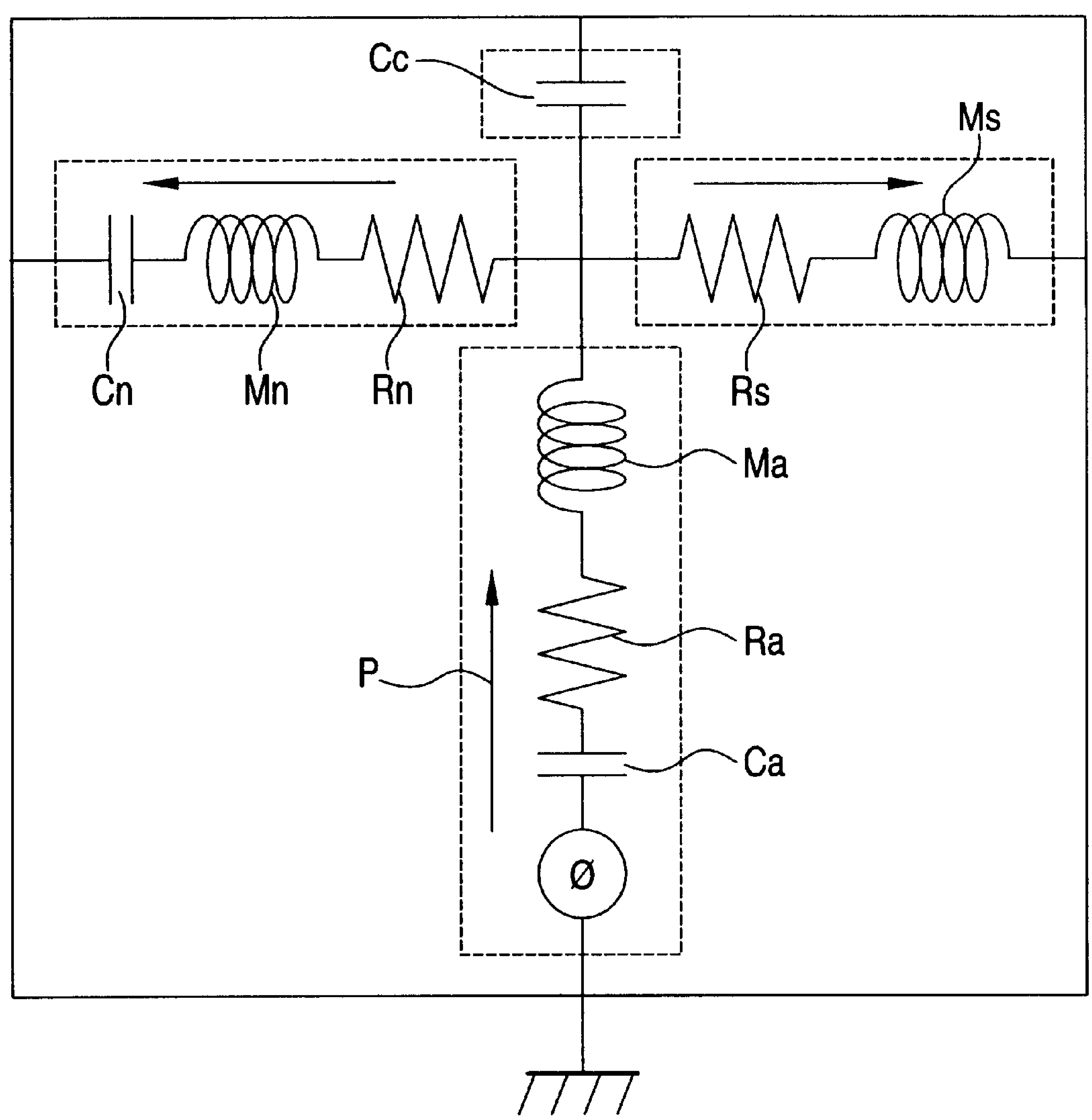
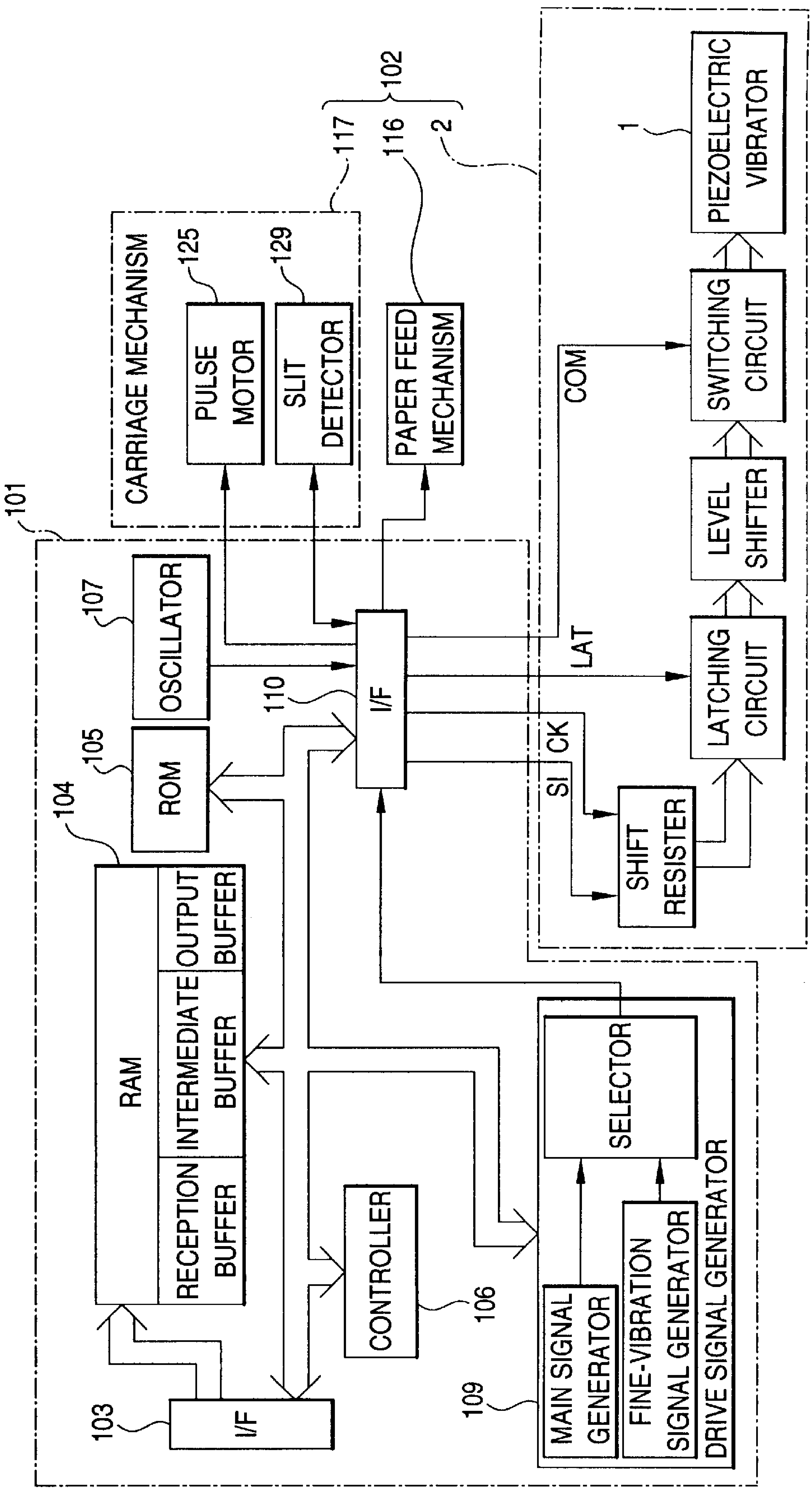


FIG. 4



102
117
116
2
1
CARRIAGE MECHANISM
PULSE MOTOR
125
SLIT DETECTOR
129
PAPER FEED MECHANISM
PIEZOELECTRIC VIBRATOR
SWITCHING CIRCUIT
LEVEL SHIFTER
LATCHING CIRCUIT
SHIFT RESISTER
COM
LAT
SI
CK
101
OSCILLATOR
107
ROM
105
I/F
110
104
RAM
RECEPTION BUFFER
INTERMEDIATE BUFFER
OUTPUT BUFFER
CONTROLLER
106
I/F
103
SELECTOR
MAIN SIGNAL GENERATOR
FINE-VIBRATION SIGNAL GENERATOR
DRIVE SIGNAL GENERATOR
109

FIG. 5A

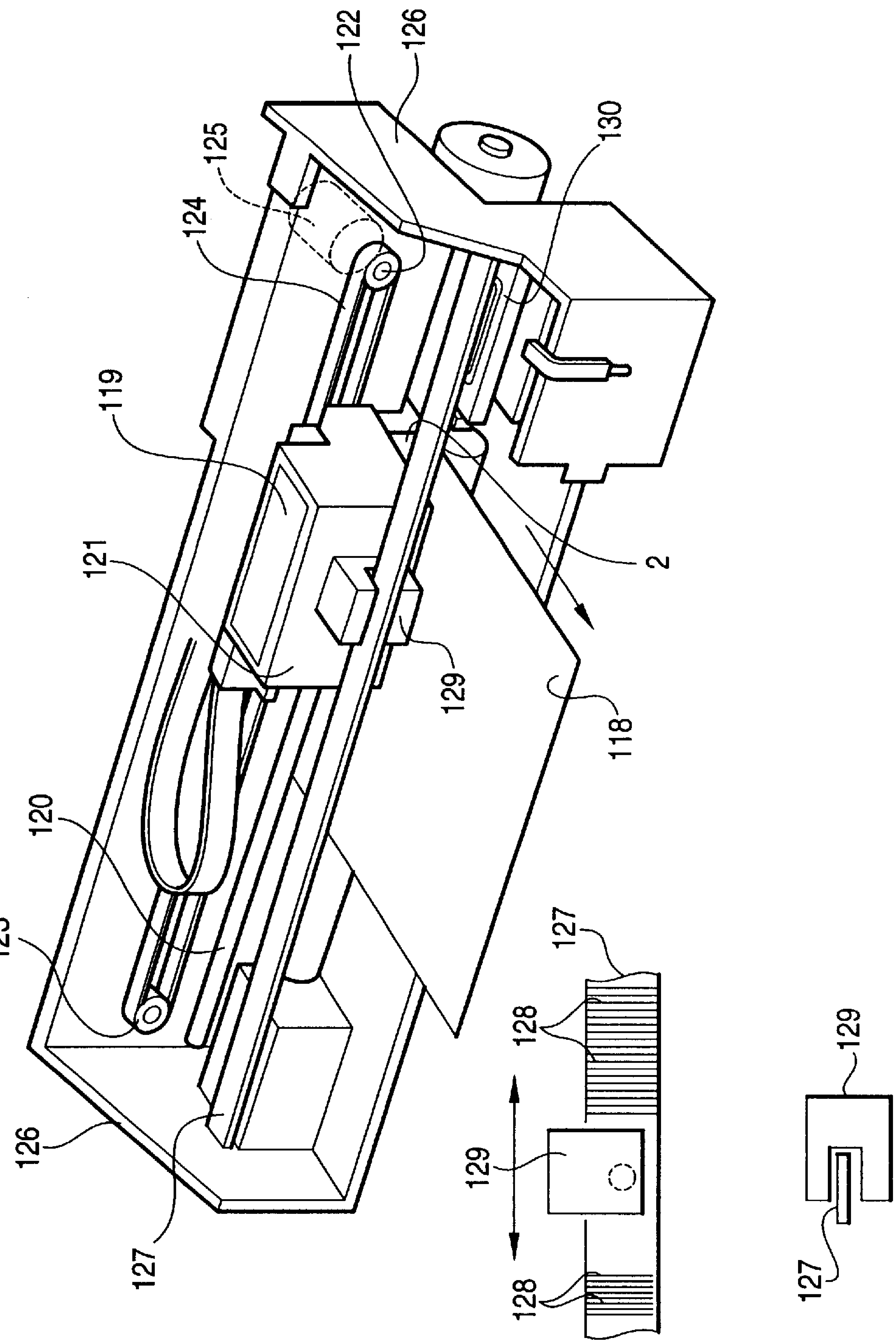


FIG. 5B

FIG. 5C

INK JET RECORDING HEAD AND IMAGE RECORDING APPARATUS INCORPORATING THE SAME

BACKGROUND OF THE INVENTION

The present invention relates to an ink jet recording head used with an ink jet printer, or the like.

In an ink jet recording head in a related art, for example, in an ink jet recording head using a piezoelectric vibrator as an electromechanical transducing element, a channel formation substrate and a vibration plate are laminated on a nozzle plate with a plurality of nozzle orifices arranged in rows, forming a channel unit, which is joined to a case.

That is, the channel formation substrate is formed with pressure generating chambers like through holes communicating with the nozzle orifices, a common ink reservoir for storing ink supplied to the pressure generating chambers, ink supply ports through which the common ink reservoir and the pressure generating chambers communicate with each other, and the like, the members being defined by partition walls. The vibration plate consists of a thick portion (island portion) and a thin portion (film portion) surrounding the thick portion. Specifically, a composite plate comprising a resin film 3 to 10 μm thick and a stainless plate 20 to 50 μm thick is etched, forming the island portion with a stainless portion left and the film portion.

A nozzle plate is bonded to one side of the channel formation substrate and the vibration plate is bonded to an opposite side, thereby forming the channel unit. Piezoelectric vibrators are placed corresponding to the pressure generating chambers and are fixed to the case and the channel unit is attached to the case, whereby the piezoelectric vibrators are abutted against predetermined portions (island portions) of the vibration plate of the pressure generating chambers corresponding to the piezoelectric vibrators and are fixed.

With the described recording head, ink is supplied from the common ink reservoir to each pressure generating chamber and the vibration plate is bent by the action of the piezoelectric vibrator for pressurizing the pressure generating chamber, so that an ink drop is jetted through the nozzle orifice by the pressure.

For this kind of recording head, in recent years, an extremely high resolution, such as 720 dpi or 1440 dpi, has been demanded; moreover, a high resolution has been demanded using four color inks of black, yellow, magenta, and cyan. Thus, it becomes necessary to jet ink drops made small with several ng per dot and therefore the characteristic vibration frequency of ink in the pressure generating chamber must be raised.

However, if an attempt is made to raise the characteristic vibration frequency, the characteristic vibration frequency f varies largely depending on compliance (easy-to-deform property; represented by a unit of [m^3/Pa]) of the recording head. The relation between f and C is represented by the following equation:

$$f = \frac{1}{2\pi\sqrt{MC}}$$

here, M denotes inertance of the mass of a medium per unit length (described later). Therefore, tolerance variation at the manufacturing stage seriously affects the jet characteristic of the recording head.

That is, very high accuracy of finishing in μm units is required when cavities of the pressure generating chambers, the ink supply ports, etc., of the channel formation substrate are formed or the vibration plate is formed with the island portion.

However, when the island and film portions are formed by etching metal, variations of ±20 μm in the longitudinal direction of the island portion and ±7 μm in the widthwise direction occur and the compliance C varies due to area variations in the film portion.

The component of the compliance C of the recording head can be roughly classified into compliance C.ink of ink in the pressure generating chambers and compliance C.str of pressure generating chamber components such as the partition walls, the vibration plate, and the nozzle plate forming the pressure generating chambers.

C.ink is proportional to the pressure generating chamber volume which depends mainly on the accuracy of finishing of the channel formation substrate. Specifically, required accuracy can be provided by applying an anisotropic etching technique of silicon.

However, in the film portion of the vibration plate (portion where C.str makes up the greatest percentage), it is hard to lessen the variations in the compliance caused by tolerance variations as described above.

In the recording head in the related art, the ink compliance C.ink makes up 20% to 45% of the compliance of the whole head, compliance C.cav of the partition walls and nozzle plates of the pressure generating chambers makes up 2%, and compliance C.film of the vibration plate makes up 53% to 78%; the compliance C.str of the pressure generating chamber components (C.cav+C.film) makes up about 50% to 80%.

Thus, if the recording head is made up of the vibration plate, the channel formation substrate, etc., worked under the tolerance as described above, it is not easy to place the compliance for each assembled recording head in a predetermined range; particularly, the recording head compliance largely varies depending on how the vibration plate is worked.

The recording head with the compliance C.str of the pressure generating chamber components out of a predetermined range becomes a defective piece. Therefore, yield lowers if an attempt is made to raise the characteristic vibration frequency of ink in the pressure generating chamber for providing a high resolution as mentioned above.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide an ink jet recording head for making it possible to decrease variations in the compliance of the recording head without depending only on accuracy of finishing and suppress occurrence of recording heads which become defective pieces for improving yield.

In order to achieve the above object, there is provided an ink jet recording head comprising:

an electromechanical transducing element;

a nozzle plate provided with a plurality of nozzle orifices;

a channel forming substrate including:

- partition walls defining a plurality of pressure generating chambers arranged so as to correspond to the nozzle orifices; and
- ink supply ports for supplying ink into associated pressure generating chambers;

a vibration plate composing a part of an inner wall of the respective pressure generating chambers for being flexed by deformation of the electromechanical transducing element to varying the volume of the respective pressure generating chambers; and

a compliance component including:

a first compliance component comprising at least one member composing the respective pressure generating chambers; and

a second compliance component comprising the ink in the respective pressure generating chambers, and being larger than the first compliance component.

For example, the first compliance component may include the partition walls and the vibrating plate.

Specifically, the second compliance component accounts for more than 45% of the compliance component.

Accordingly, the percentage of the compliance varying depending on the accuracy of finishing of the channel formation substrate and the vibration plate lessens relatively. Therefore, if the parts are worked under the tolerance in the related art, the compliance of the recording head is less affected. Thus, the compliance for each manufactured recording head easily enters a predetermined range, so that occurrence of defective pieces can be suppressed for improving yield.

In order to increase the relative percentage of the second compliance component, the volume of the respective pressure generating chamber is increased.

Accordingly, the compliance of the recording head can be stabilized without making the accuracy of finishing specially strict.

In order to increase the volume of the respective pressure generating chambers, thickness of the channel forming substrate is thickened.

Accordingly, if a silicon wafer is used to form the channel formation substrate, rapid cost increase can be avoided and miniaturization of the recording head can be maintained.

In order to obtain the relative higher percentage of the second compliance component, thickness of the vibrating plate is thickened so as to lower a relative percentage of the first compliance component.

Accordingly, stabilization of the compliance of the recording head can be accomplished easily.

In the recording head, the vibration plate is composed of a resin film and a metal layer.

Accordingly, it is easy to relatively lower the percentage of the compliance of the vibration plate by using a thick resin film.

In the recording head, the electromechanical transducing element is a piezoelectric vibrator.

In the recording head, the pressure generating chambers and the ink supply ports are formed by etching a silicon wafer anisotropically.

Accordingly, extremely high accuracy of finishing is provided easily.

According to the present invention, there is provided an image recording apparatus comprising an ink jet recording head as described above.

In the recording head, the respective pressure generating chambers may be partitioned into a plurality of chambers in a deforming direction of the electromechanical transducing element which are communicated with each other by a through hole.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. **1** is a sectional view of an ink jet recording head;

FIG. **2**A is a plan view of a pressure generating chamber, FIG. **2**B is a sectional view of the recording head taken along the line b—b in FIG. **2**A, and FIG. **2**C is a sectional view of the recording head taken along the line c—c in FIG. **2**A;

FIG. **3** is a schematic diagram representing a vibration system in the recording head by an equivalent circuit;

FIG. **4** is a block diagram to describe the configuration of an ink jet printer;

FIG. **5**A is a perspective view showing the internal mechanism of the ink jet printer; and FIGS. **5**B and **5**C are a plan view and a sectional view showing the slit detector in the ink jet printer, respectively.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the accompanying drawings, there is shown an embodiment of the invention. First, an ink jet printer as an image recording apparatus to which the present invention is applied will be discussed with reference to FIGS. **4** and **5**.

As shown in FIG. **4**, the ink jet printer is roughly made up of a printer controller **101** and a print engine **102**.

The printer controller **101** comprises an external interface **103** (external I/F **103**), RAM (random access memory) **104** for temporarily storing various pieces of data, ROM (read-only memory) **105** for storing a control program, etc., a controller **106** containing a CPU (central processing unit), etc., an oscillator **107** for generating a clock signal, a drive signal generator **109** for generating a drive signal supplied to a recording head **2**, and an internal interface **110** (internal I/F **110**) for transmitting the drive signal and dot pattern data (bit map data) expanded based on print data and the like to the print engine **102**.

The external I/F **103** receives print data made up of character code, a graphic function, image data, etc., for example, from a host computer (not shown), etc. A busy signal (BUSY) and an acknowledge signal (ACK) are output through the external I/F **103** to the host computer, etc.

The RAM **104** functions as a reception buffer, an intermediate buffer, an output buffer, and work memory (not shown). The reception buffer temporarily stores the print data received through the external I/F **103**, the intermediate buffer stores intermediate code data provided by the controller **106**, and the output buffer stores dot pattern data. The dot pattern data is print data provided by decoding (translating) gradation data.

The ROM **105** stores font data, graphic functions, etc., in addition to the control program (control routine) for performing various types of data processing.

The controller **106** performs various types of control. In addition, it reads the print data in the reception buffer and stores the intermediate code data provided by converting the print data in the intermediate buffer. Also, the controller **106** analyzes the intermediate code data read from the intermediate buffer, references the font data, graphic function, etc., stored in the ROM **105**, and expands the intermediate code data into dot pattern data. After performing necessary decoration processing, the controller **106** stores the dot pattern data in the output buffer.

If one line of the dot pattern data that can be recorded by one main scanning of the recording head **2** is provided, it is output from the output buffer through the internal I/F **110** to the recording head **2** in sequence. When one line of the dot pattern data is output from the output buffer, the already expanded intermediate code data is erased from the intermediate buffer and the next intermediate code data is expanded.

The drive signal generator **109** comprises a main signal generator for generating a jetting drive signal used for recording, a fine-vibration signal generator for generating a non-print fine-vibration signal and a pre-print fine-vibration signal for finely vibrating a meniscus (free surface of ink exposed on nozzle orifice) for agitating ink in the nozzle orifice, and a selector, to which the jetting drive signal from the main signal generator and the out-of-print fine-vibration signal or the before-print fine-vibration signal from the fine-vibration signal generator are input, for selectively outputting the input signal to the internal I/F **110**.

The print engine **102** comprises a paper feed mechanism **116**, a carriage mechanism **117**, and the above-mentioned recording head **2**.

The paper feed mechanism **116** is made up of a paper feed motor, a paper feed roller, etc. As shown in FIG. **5**A, it feeds record paper **118** (a kind of print record medium) in sequence in association with the record operation of the recording head **2**. That is, the paper feed mechanism **116** moves the record paper **118** in the record paper feed direction, which is a subscanning direction.

The carriage mechanism **117** comprises a carriage **121** on which the recording head **2** and an ink cartridge **119** can be mounted, the carriage **121** being attached to a guide member **120** movably, a timing belt **124** placed on a drive pulley **122** and a driven pulley **123** and connected to the carriage **121**, a pulse motor **125** for rotating the drive pulley **122**, a linear encoder **127** placed on a printer cabinet **126** in parallel with widthwise direction of the record paper (along the main scanning direction), and a slit detector **129** attached to the carriage **121** and capable of detecting a slit **128** of the linear encoder **127**.

The linear encoder **127** of the embodiment is a transparent thin plate member formed with slits **128** . . . at pitches of 360 or 360/N (dpi), as shown in FIGS. **5**B and **5**C. The slit detector **129** is made of a photointerruptor, for example.

In the carriage mechanism **117**, the carriage **121** is reciprocated along the widthwise direction of the record paper **118** by the operation of the pulse motor **125**. That is, the recording head **2** mounted on the carriage **121** is moved along the main scanning direction. The carriage **121** is moved with a reference position on the home position side as the starting point. The home position is a position at which the carriage **121** is placed in a standby state if a no-power state or a no-recording state continues for many hours. In the embodiment, the right end part in FIG. **5**A is the home position, where a capping mechanism **130** is provided for preventing an ink solvent from evaporating in nozzle orifice **11** (described later) of the recording head **2**. The reference position is set to a left position a little from the home position. Specifically, the reference position is set where the recording head **2** is positioned between the right margin of the record paper **118** and the capping mechanism **130**.

The recording head **2** is reciprocated along the main scanning direction from the reference position and ink drops are jetted from the recording head **2** in association with the reciprocation. Further, the record paper **118** is moved in the record paper feed direction, whereby any desired image can be recorded on the record paper **118**.

Next, the described recording head **2** will be discussed in detail.

FIG. **1** is a sectional view of one embodiment of the ink jet recording head **2** using a piezoelement (PZT) of a representative piezoelectric vibrator **1** as an electromechanical transducing element. FIG. **2**A is a plan view of a pressure generating chamber and FIGS. **2**B and **2**C are enlarged sectional views to show the main part of the recording head **2** shown in FIG. **1**.

As shown in FIG. **1**, to form the recording head **2**, the piezoelectric vibrator **1** is inserted into a chamber **4** of a case **3** shaped like a plastic box, for example, through one opening, a tip **1***a* shaped like comb teeth is made to face an opposite opening, a channel unit **5** is joined to the surface (bottom face) of the case **3** on the opening side, and the tip **1***a* of the piezoelectric vibrator **1** is abutted against and fixed to a predetermined portion of the channel unit **5**. In FIG. **1**, numeral **6** denotes a flexible cable and numeral **7** denotes a fixed substrate.

The channel unit **5** comprises a nozzle plate **9** and a vibration plate **10** laminated on both sides with a channel formation substrate **8** in between.

The nozzle plate **9** is a stainless thin plate with a plurality of nozzle orifices **11** arranged in rows at pitches corresponding to the dot formation density; in the embodiment, it is formed with five rows of nozzle orifices **11** (96 nozzle orifices per row) made at the pitches of about 0.141 mm (180 dpi).

As shown in FIG. **2**, the channel formation substrate **8** laminated on one face of the nozzle plate **9** is a plate-like member formed with cavities which is to be pressure generating chambers **13** corresponding to the nozzle orifices **11** in the nozzle plate **9** in a state in which the cavities are partitioned by partition walls **12**, and formed with cavities which become ink supply ports **14** and a common ink reservoir **15**. Each pressure generating chamber **13** is a chamber elongated in a direction orthogonal to the nozzle orifice row; a part of the pressure generating chamber **13** is formed of a through hole **16** which is roughly parallelogrammatic in cross section piercing the channel formation substrate **8** in the thickness direction thereof and the remaining part is formed of a flat concave chamber partitioned up and down by a partition wall **17** formed at the center in the thickness direction of the channel formation substrate **8**.

The pressure generating chamber **13** shown in FIG. **2** is 1216 μm long and 100 μm wide on the nozzle plate **9** side and 110 μm wide on the vibration plate **10** side, the through hole **16** is 100 μm long and 80 μm wide, the partition wall **12** on the nozzle plate **9** side is 41 μm thick, the partition wall **12** on the vibration plate **10** side is 31 μm thick, and the partition wall **12** of the part of the through hole **16** is 61 μm thick. Numeral **18** denotes a gate formed in the channel from the common ink reservoir **15** to the pressure generating chamber **13** and the gate **18** forms an ink supply passage **14** in the form of a narrow part having a narrow channel width.

The through hole **16**, the pressure generating chamber **13**, the ink supply port **14**, and the common ink reservoir **15** of the channel formation substrate **8** are formed for each nozzle orifice **11** by etching a silicon wafer. In the embodiment, the channel formation substrate **8** is made thick, whereby the volume of each pressure generating chamber **13** is increased, whereby the percentage of the compliance of ink in the pressure generating chamber **13** (described later) is made large.

In the embodiment, the through hole **16** is made at one end of the pressure generating chamber **13**, namely, at the furthermost portion from the common ink reservoir **15** in the pressure generating chamber **13**. The ink supply port **14** is connected to an opposite end of the pressure generating chamber **13** and the nozzle orifice **11** is formed in the proximity of the end part on the opposite side to the ink supply port **14**. In the embodiment, the nozzle orifice **11** is positioned almost at the center of the through hole **16**.

The common ink reservoir **15** is a chamber for supplying ink stored in an ink cartridge (not shown) to each pressure generating chamber **13**, and an ink supply tube **19** communicates almost at the center in the longitudinal direction.

In the embodiment, the vibration plate **10** serves as both a seal plate being laminated on an opposite face of the channel formation substrate **8** positioned on the opposite side to the nozzle plate **9** for sealing one opening face of the pressure generating chamber **13** and an elastic film (thin film portion) being laminated on the opposite face of the channel formation substrate **8** for sealing one opening face of the common ink reservoir **15** and is of a double structure comprising a polymer film **21** of PPS, etc., laminated on a stainless plate **20**. Since both the seal plate and the elastic film are formed of the same member, the stainless plate **20** of the portion functioning as the seal member, namely, the portion corresponding to the pressure generating chamber **13** is etched to form a thick portion (island portion **22**) for abutting and fixing the tip of the piezoelectric vibrator **1**, and the stainless plate **20** of the portion functioning as the elastic film, namely, the portion corresponding to the common ink reservoir **15** is removed by etching for leaving only film portion **21** (elastic film).

In the embodiment, the film portion **21** of the vibration plate **10** is made thick, whereby the percentage of the compliance of the vibration plate **10** is relatively lowered and the percentage of the compliance of ink in the pressure generating chamber **13** is relatively raised. Specifically, formerly a polymeric film of PPS (polyphenylene sulfide), polyimide, etc., 3.5 μm thick was used as film portion **21**; in the embodiment, the film 6 μm thick (twice as thick as the former film) is used.

In the described recording head **2**, the piezoelectric vibrator **1** is expanded in the longitudinal direction of the vibrator whereby the island portion **22** is pressed against the nozzle plate **9**, the film portion (elastic film) **21** surrounding the island portion **22** becomes deformed, and the pressure generating chamber **13** is contracted. If the piezoelectric vibrator **1** is contracted in the longitudinal direction of the vibrator, the pressure generating chamber **13** is expanded due to elasticity of the film portion **21**. Expansion and contraction of the pressure generating chamber **13** are controlled, whereby an ink drop is jetted through the nozzle orifice **11**.

A vibration system in the recording head **2** can be represented by an equivalent circuit shown in FIG. **3**. Here, symbol M denotes inertance of the mass of a medium per unit length [Kg/m^4], symbol Ma denotes inertance in the piezoelectric vibrator **1**, symbol Mn denotes inertance in the nozzle orifice **11**, nd symbol Ms denotes inertance in the ink supply port **14**. Symbol R denotes resistance of the internal loss of a medium [$N \cdot s/m^5$], symbol Rn denotes resistance in the nozzle orifice **11**, and symbol Rs denotes resistance in the ink supply port **14**. Symbol C denotes compliance of volume change per unit pressure [m^5/N], symbol Cc denotes compliance of the vibration plate **10** and the partition wall **12** forming the pressure generating chamber **13**, symbol Ca denotes compliance in the piezoelectric vibrator **1**, and symbol Cn denotes compliance in the nozzle plate **9**. Symbol P denotes pressure generated with time by the piezoelectric vibrator **1**, in other words, equivalent pressure into which voltage pulses applied to the piezoelectric vibrator **1** are converted.

The compliance of ink in the pressure generating chamber **13**, C.ink, can be represented as in the following expression (1):

$$C.ink = \frac{V}{\rho c^2} \quad (1)$$

where V is the volume [m^3] of the pressure generating chamber **13**, ρ is the ink density [Kgf/m^3], and c is the velocity [m/s] of sound in liquid.

Here, ρ and c are constant and thus C.ink can be represented as:

$$C.\text{ink}=kV\ (k\text{: constant}) \quad (2)$$

Therefore, variations in C.ink are mainly caused by the volume of the pressure generating chamber **13**. Variations in the volume of the pressure generating chamber **13** depend on the accuracy of finishing of the channel formation substrate **8**, but extremely high accuracy can be easily provided by applying an anisotropic etching technique of silicon.

The compliance of the pressure generating chamber **13** relates to each compliance of the nozzle plate **9**, the vibration plate **10**, and the partition wall **12** of the channel formation substrate **8** forming the pressure generating chamber **13**, namely, functioning as the inner wall face of the pressure generating chamber **13**. Letting the compliance of the pressure generating chamber components be C.str, this C.str is volume change ΔV relative to pressure change ΔP and can be represented as in the following expression (3):

$$C.str = \frac{\Delta V}{\Delta P} \quad (3)$$

As described above, almost all of C.str depends on compliance C.film of the film portion of the vibration plate **10**. C.film is proportional to the cube of the thickness of the film portion **21** and proportional to the fifth power of the width, thus variations in C.str are made large with respect to shape variations.

If, of the compliance component of the recording head **2**, the percentage of the compliance C.ink of ink in the pressure generating chamber **13** is made larger than the percentage of the compliance C.str of the pressure generating chamber components such as the partition wall **12** and the vibration plate **10** forming the pressure generating chamber (C.ink>C.str), the compliance of the recording head becomes hard to be affected by the accuracy of finishing of the pressure generating chamber components such as the partition wall **12** of the channel formation substrate **8** and the vibration plate **10**, particularly the work state of the island portion **22** of the vibration plate **10** and an error of the thickness of the film portion **21**. In other words, increasing relatively the percentage depending on the compliance of ink in the pressure generating chamber **13** out of the factors determining the compliance of the recording head **2**, the percentage depending on the accuracy of finishing of the vibration plate **10** of the recording head **2** is relatively lowered, whereby variations in the compliance of the recording head **2** can be lessened.

To increase the compliance of ink in the pressure generating chamber **13**, the volume of the pressure generating chamber **13** may be increased as seen from expression (2).

Specifically, in the embodiment, as described above, the silicon wafer of the channel formation substrate **8** is made thick, whereby the volume in the pressure generating chamber **13** is increased about 40% to 80%, so that the percentage of the compliance of ink in the pressure generating chamber **13** is raised.

To increase the volume in the pressure generating chamber **13**, the length in the longitudinal direction may be extended; however, it is desirable to thicken the silicon wafer of the channel formation substrate **8** considering miniaturization of the recording head **2** and the silicon wafer yield.

As described above, in the embodiment, the vibration plate **10** is made thick and thus the compliance of the vibration plate **10** becomes smaller than that in the related art, so that the compliance C.str of the pressure generating chamber components decreases, the percentage of the ink compliance C.ink in the pressure generating chamber **13** is still more raised, and variations in the compliance of the recording head **2** can be still more lessened.

Since the compliance of the vibration plate **10** accounts for most of the compliance C.str of the pressure generating chamber components, it is important to thicken the vibration plate **10** to relatively decrease the percentage of the compliance C.str of the pressure generating chamber components.

Thus, in the recording head **2** shown in the embodiment, the volume in the pressure generating chamber **13** is increased and the vibration plate **10** is thickened, whereby the compliance C.film of the vibration plate **10** becomes 29%, the compliance C.cav of the pressure generating chamber **13** of the partition wall **12**, etc., becomes 2%, and the ink compliance C.ink in the pressure generating chamber **13** becomes 69%; the compliance C.str of the pressure generating chamber components becomes 31%. Therefore, the relation of C.ink>C.str is satisfied and when the recording head **2** is assembled, compliance can be easily stabilized. Thus, it contributes greatly to improvement in yield.

The scope of the invention is not limited to the dimensions mentioned in the embodiment and the relation of C.ink>C.str needs only to be true. In the embodiment, the piezoelectric vibrator **1** formed of the vibrator like comb teeth in so-called vertical vibration mode comprising the piezoelectric body and internal electrode laminated in the direction orthogonal to the expansion and contraction direction of the vibrator is taken as an example. However, the invention can also be applied to a piezoelectric vibrator **1** in so-called deflection vibration mode comprising the piezoelectric body and internal electrode laminated in the expansion and contraction direction of the vibrator. Further, the electromechanical transducing element is not limited to the piezoelectric vibrator and may be an element which produces mechanical deformation as a drive signal is applied.

What is claimed is:

1. A system containing an ink jet recording head and ink, the system comprising:

ink;

an ink jet recording head, wherein the ink jet recording head further comprising:

a channel forming substrate formed with partition walls defining at least one pressure generating chamber therein;

at least one electromechanical transducing element associated with each pressure generating chamber;

a nozzle plate composing a part of an inner wall of the at least one pressure generating chamber; the nozzle plate formed with at least one nozzle orifice communicated with each associated pressure generating chamber;

a vibration plate composing a part of an inner wall of the at least one pressure generating chamber for being flexed by deformation of the electromechanical transducing element to varying the volume of the associated pressure generating chamber;

wherein compliance components of the system comprise:

a first compliance component composed of a compliance component of the partition walls of the channel forming substrate, a compliance component of the nozzle plate and a compliance component of the vibration plate, the compliance component of the vibration plate being larger than each of the compliance component of the partition walls and the compliance component of the nozzle plate; and

a second compliance component corresponding to the ink contained in the at least one pressure generating chamber, the second compliance component being larger than the first compliance component.

2. The system as set forth in claim **1**, wherein the volume of the at least one of the pressure generating chambers is determined so as to increase the relative percentage of the second compliance component.

3. The system as set forth in claim **2**, wherein thickness of the channel forming substrate is thickened so as to increase the volume of the at least one of the pressure generating chambers.

4. The system as set forth in claim **1**, wherein thickness of the vibrating plate is thickened so as to lower a relative percentage of the first compliance component to obtain the bid relative higher percentage of the second compliance component.

5. The system as set forth in claim **1**, wherein the electromechanical transducing element is a piezoelectric vibrator.

6. The system as set forth in claim **1**, wherein the pressure generating chambers and the ink supply ports are formed by etching a silicon wafer anisotropically.

7. The system as set forth in claim **4**, wherein the vibration plate is composed of a resin film and a metal layer.

8. The system as set forth in claim **1**, wherein the second compliance component accounts for more than 45% of the compliance component.

9. The system as set forth in claim **1**, wherein the at least one of the pressure generating chambers are partitioned into a plurality of chambers in a deforming direction of the electromechanical transducing element which are communicated with each other by a through hole.

10. The system as set forth in claim **1**, wherein the first compliance component includes the partition walls and the vibrating plate.

11. An image recording apparatus comprising the system as set forth in any one of claims **1** to **10**.

12. The system according to claim **1**, wherein the first compliance component corresponds to a ratio of the change in volume of the at least one of the pressure generating chambers to the change in pressure of the at least one of the pressure generating chambers.

13. The system according to claim **1**, wherein the second compliance component corresponds to a ratio of the volume of the at least one of the pressure generating chambers to an ink density.

14. A system containing an ink jet recording head and ink, the system comprising:

ink; and

an ink jet recording head, including:

a channel forming substrate, formed with partition walls defining at least one pressure generating chamber therein;

at least one electromechanical transducing element, associated with each pressure generating chamber;

a nozzle plate, composing a part of an inner wall of the at least one pressure generating chamber, the nozzle plate formed with at least one nozzle orifice communicated with each associated pressure generating chamber; and

a vibration plate, composing a part of an inner wall of the at least one pressure generating chamber for being flexed by deformation of the electromechanical transducing element to varying the volume of the associated pressure generating chamber, the vibration plate formed with a first portion having a first thickness and a second portion having a second thickness larger than the first thickness,

wherein compliance components of the system comprise:

a first compliance component corresponding to the partition walls of the channel forming substrate, the nozzle plate and the vibration plate; and

a second compliance component corresponding to the ink contained in the at least one pressure generating chamber, the second compliance component being larger than the first compliance component.

15. The system as set forth in claim **14**, wherein the volume of the at least one of the pressure generating chambers is determined so as to increase the relative percentage of the second compliance component.

16. The system as set forth in claim **14**, wherein a thickness of the channel forming substrate mainly determines the volume of the at least one of the pressure generating chambers is determined.

17. The system as set forth in claim **14**, wherein a compliance component corresponding to the vibration plate is smaller than the second compliance component.

18. The system as set forth in claim **17**, wherein the compliance component corresponding to the vibration plate is mainly determined by a thickness of the first portion of the vibration plate.

19. The system as set forth in claim **14**, wherein the at least one of the electromechanical transducing element is a piezoelectric vibrator.

20. The system as set forth in claim **14**, wherein the channel forming substrate is formed by anisotropically etching a silicon substrate.

21. The system as set forth in claim **14**, wherein the vibration plate includes a first layer having the first thickness and a second layer laminated on the first layer so as to have the second thickness.

22. The system as set forth in claim **21**, wherein:

the channel forming substrate is formed with partition walls defining therein a common ink reservoir which stores ink to be supplied to the respective pressure generating chambers; and

the first layer extends so as to compose a part of an inner wall of the common ink reservoir.

23. The system as set forth in claim **21**, wherein the first layer is a resin film and the second layer is a metal layer.

24. An ink jet recording apparatus comprising the system as set forth in any one of claims **14** to **23**.

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